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(54) Firing systems including a controller which is connectable by electrical wires

(57) A method and system for causing a multi-shot blast is disclosed and claimed. According to the method, suitable positions for detonators 14.1 to 14.8 are determined in situ. Position related data (x;y) is determined automatically for each position utilizing a GPS system and also identification code data of each detonator. This data is transferred to a controller 16 via a data-capturing device 18. The controller establishes a blast programme including inter hole delay times calculated by taking into account the position related data, geological structure, hole depth, mass of explosive in hole etc. The controller transmits signals including delay time data to the detonators, to cause them to detonate according to the programme.

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Description

INTRODUCTION AND BACKGROUND

[0001] THIS invention relates to explosive firing arrangements and more particularly to an explosive firing system comprising a plurality of electronic detonators and a controller therefor. the controller, in use, causing the detonators to initiate their associated explosive charges according to a programme in a multi-shot blast.

[0002] Firing systems including a controller which is connectable by electrical wires to a plurality of identical detonators and wherein each detonator is associated with an identification code individual thereto, are known. In use, the detonators with their associated charges are located in pre-planned positions and the electrical connection is made. Pre-computed delay time data associated with each detonator is transmitted together with the identification codes on the wires to the detonators and the delay time data associated with each detonator is stored in a memory arrangement of that detonator. Upon receipt of a common fire signal, the detonators time out the relevant delay times and then initiate their associated charges, to cause the multi-shot blast.

[0003] A disadvantage of the above system is that the exact physical location of the detonators in use and the relevant delay times must be planned and worked out in advance. The aforementioned system thus lacks flexibility and does not provide an optimum match with sophisticated blast controllers and computerized control systems which are adapted also to utilize data regarding geological structure and formations as an input for calculating delay times and which may thus allow for subsequent changes or modifications to a delay time program, to optimize the programme.

OBJECT OF THE PRESENT INVENTION

[0004] Accordingly it is an object of the present invention to provide a method and system with which the applicant believes the aforementioned shortcomings may at least be alleviated.

SUMMARY OF THE INVENTION

[0005] According to the invention there is provided a method of causing a multi-shot blast including the steps of:

- selecting a plurality of spaced positions for locating electronic detonators in a blast site;
- at each position, determining position related data for that detonator position;
- utilizing the position related data to establish a blast programme
- providing signals to detonators at the detonator positions, to cause them to detonate according to the programme.

[0006] It will be appr ciated that the method according to the inv ntion provides more flexibility in that once the detonators are positioned, their position data and other data, such as geological data, may b utilized to compute delay time data for each detonator position, to cause a desired firing sequence and hence blast front.

[0007] Further according to the invention the method may include the step of determining identification code data of each of the detonators before establishing the blast programme. The identification code data may be determined by reading the data electronically from a memory arrangement in the detonator. However, the step of determining detonator identification code data preferably includes determining the data passively. In this specification the term "determining the data passively" will mean that the data is determined without electrically energizing the detonator. For example, the data may be determined passively by reading identification code data provided on the detonator in the form of a bar code pattern, by means of a bar code reader.

[0008] The position related data may be determined by absolute position monitoring, alternatively by distance-related monitoring by determining distances between the detonator positions. The position related data may be determined automatically utilizing any suitable measuring means such as a radio device, an acoustic device, an optical device, a laser operated device. In a preferred form of the invention, absolute position related data is determined by determining position coordinate data for each detonator position. The position coordinate data is preferably determined utilizing a global positioning system (GPS) including a GPS receiver and at least one earth orbiting satellite.

[0009] In the method according to the invention the position related data and identification code data may be captured at the detonator positions in a data reading, storing and downloading device.

[0010] The captured data may then be downloaded into a remote central controller for establishing the blast programme upon inputting of the data into the controller.

[0011] The step of providing signals to the detonators may include the step of transmitting to each of the detonators, utilizing its respective identification code data as an address, delay item data relating to a delay time from a common fire signal for each detonator to detonate.

[0012] Further according to the invention and before the delay time data is transmitted to the detonators, the detonators may be energized by transmitting an energizing signal to the detonators.

[0013] The detonators may be energized via electrical wiring extending between the controller and the detonators. In an alternative embodiment the detonators may be energized by transmitting a wireless energizing signal, such as a radio frequency (RF) energizing signal to the detonators.

[0014] The delay time data may also be transmitted on the electrical wiring connecting the detonators to the

central controll r. In the alternative embodim nt the data may be transmitted by wireless transmission.

[0015] The common fire signal may also be transmitted on the wiring, alternatively in the form of a wireless signal

[0016] Also included within the scope of the invention is a method of timing a multi-shot blast including the steps of:

- locating a detonator arrangement including a detonator having a preprogrammed identification code; and an associated explosive charge, in each of a plurality of spaced detonator positions;
- at each position, determining respective detonator identification code data relating to the detonator at that position and respective position related data for that detonator position;
- transferring the respective detonator identification code data and respective position related data to a central controller;
- computing for each detonator position, data relating to a respective delay time from reception of a common fire signal after which the detonator at that detonator position must cause its associated charge to explode;
- utilizing the respective detonator identification code data and transmitting the respective delay time data to each detonator at said detonator positions; and
- transmitting a common fire signal to each detonator, to cause its associated charge to explode after the respective delay time computed for that detonator position.

[0017] Yet further included within the scope of the present invention is a method of preparing a blast site, the method including the steps of:

- selecting a plurality of spaced positions for locating electronic detonators;
- at each position, determining position related data for that detonator position; and
- transferring the position related data to a central controller.

[0018] Still further included within the scope of the present invention is a method of causing a multi-shot blasting operation of a series of explosive charges spaced apart from each other at a blast site, said method including the steps of:

- automatically determining position related data at each charge location;
- determining from the positional data a required firing sequence; and
- applying the firing sequence to the series of charges.

[0019] The automatic determination of position related data at each charge location may be obtained using one of: a radio devic ; an acoustic device; an optical device; a laser op rated device; or a global positioning system receiver.

[0020] The position related data may be determined by absolute position monitoring. Alternatively, the position related data may be determined by distance-related monitoring.

[0021] The required firing sequence may be determined from the positional data by manual or automatic inputting of the data to a data store.

[0022] The data store may be connected to, or incorporated in a remote controller which is operative to send sequential firing signals to the individual charges according to the required firing sequence. Alternatively, the data store may supply respective firing sequence data to individual local controllers associated one with each charge, and upon issue of a common firing signal to the local controllers, sequential firing of the charges takes place according to the required firing sequence.

[0023] According to another aspect of the invention there is provided an explosive firing system including:

- a plurality of detonators;
- a central controller for controlling operation of the detonators;
- position determining means for determining position related data for each of a plurality of suitable positions for the detonators in a blast area;
- the central controller being arranged to utilize said position related data to compute a blast programme;
- means for transferring signals relating to the blast programme to the detonators to cause them to detonate in accordance with the blast programme.

[0024] The controller, in computing the blast programme, may compute for each position, delay time data relating to a delay time from reception of a common fire signal after which a detonator at that position must cause an associated charge to explode.

[0025] The system may further include means for inputting identification code data associated with each detonator. The means for inputting the identification code data may include a bar code reader for reading a bar code pattern applied on each detonator. In another embodiment the identification code data may be read electronically from a memory arrangement forming part of the detonator.

[0026] The position determining means is preferably automatic position data determining means and may include a global positioning system (GPS) including a GPS receiver cooperating with at least one earth orbiting satellite. In other embodiments the position determining means may include a radio device, an acoustic devic , an optical device or a laser operated device.

[0027] The position determining means may be mounted on a boring machine for drilling holes wherein

the detonators and associated explosive charges are to be positioned. Alternatively, it may be mounted on a vehicle transporting the explosive charges and detonators. Further alternativ ly, it may be carried in a carrier or harness mountable on the body of a person preparing the blast site.

[0028] The system may further include a data capturing device for receiving position related data and identification code data at the detonator positions and which device is connectable to the central controller for downloading said data into the central controller. The central controller is preferably adapted automatically to determine the blast programme by inputting the position-related data there into.

[0029] The means for transferring the delay time data and/or an energizing signal and/or the fire signal or signals may include a wired or fiber communication path, alternatively it may comprise a wireless, more particularly radio frequency (RF) communication system.

BRIEF DESCRIPTION OF THE ACCOMPANYING DIAGRAMS

[0030] The invention will now further be described, by way of example only, with reference to the accompanying diagrams wherein:

figure 1 is a diagrammatic plan view of an open-pit mine showing a plurality of holes drilled therein to receive explosive charges and with an imaginary grid superimposed thereon, to indicate the position of each hole;

figure 2 is a block diagram of a first embodiment of a firing system according to the invention;

figure 3 is a block diagram of a detonator forming part of the system; and

figure 4 is a block diagram of an alternative embodiment of the system according to the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0031] An open-pit mine is generally designated by the reference numeral 10 in figure 1.

[0032] Multi-shot blasting techniques are used not only to break up earth layers to a level close to a reef or the like to be mined, but also to move the broken-up ground away from the reef, to expose the reef. To accomplish this, positioning of holes for receiving the explosives and inter-hole delay times, that is delay times between shots in the blast, need careful planning.

[0033] In the method according to the invention, positions for the holes 12.1 to 12.8 are selected in situ. The holes are then drilled by a suitable boring machine to a required depth. The depth of the holes may differ from one another depending on the geological structure of the earth below the surface.

[0034] Detonators 14.1 to 14.8 (shown in figure 2) are then inserted into holes 12.1 to 12.8 respectively and the holes are stemmed with explosiv charges. The detonators are identical, except that each is associated with a preprogrammed identification code (DET #1 to DET #8) individual thereto.

[0035] In an absolute position monitoring step position related data, more particularly data relating to position co-ordinates of the holes $(x_1;y_4)$ etc, are determined automatically in known manner, utilizing, for example, a Global Positioning System (GPS) comprising a GPS receiver 19 (shown in figure 2) and a network of earth orbiting satellites. The GPS receiver may be mounted on the boring machine or a vehicle carrying the explosive charges and detonators or in a suitable carrier or harness for the receiver mountable on the back of a person preparing the holes. In other embodiments, the position related data may be determined by distance related monitoring, more particularly by determining inter-hole distance-related data, by utilizing, for example, one of a radio device, an acoustic device, an optical device or a laser operated device.

[0036] In a further step, the identification numbers of the detonators 14.1 to 14.8 in each of the holes 12.1 to 12.8 are determined, for example by electronically reading it or preferably by reading it passively; for example by reading by means of a bar code reader 36, a bar code pattern 34 on the body or a connector (not shown) of the detonator. The identity number of the detonator, the GPS data of the hole, data regarding the depth of the relevant hole, data regarding the type and mass of explosive in the hole and data regarding geological structure are captured in a portable data capturing device 18. The device 18 is connectable to the bar code reader 36 to receive the identity number, to GPS receiver 19 to receive the position data and also to central controller 16, to download the aforementioned data.

[0037] As stated hereinbefore, the detonators are identical except for their identification numbers. Accordingly, only detonator 14.1 will be described hereinafter with reference to figure 3. Detonator 14.1 comprises a read only memory arrangement (ROM) 22 storing the preprogrammed identification code (DET #1) individual thereto, a local timer 24 for timing out a delay time, data regarding which is loaded and stored in the detonator as will hereinafter be described, a capacitor 26 for storing electrical charge and a switching arrangement 28 which, when activated by a local controller 30, causes charge stored on the capacitor to be dumped into a fusehead 32, such as a semiconductor bridge (SCB). The local controller comprises random access memory (RAM) for storing the aforementioned delay time data associated with detonator 14.1.

[0038] In the embodiment shown in figure 2, the controller 16 is connected by electrical wires 20 to the detonators 14.1 to 14.8.

[0039] As stated hereinbefore, the data capturing devic 18 is connectable to controller 16. The GPS data,

ID code data and the other data referred to hereinbefore stored in the data-capturing d vice 18 are downloaded into the controller 16. The controller 16 then utilizes the GPS data, the ID code data and the data regarding the type of explosive used, the mass of explosive per hole, depth of the hole and geological data to compute a delay time programme, comprising delay times, preferably from a common fire signal, for each of the hole positions.

[0040] An energizing signal is transmitted on the line 20 to charge the capacitor 26 of each detonator. Thereafter, data regarding the delay times is transmitted on line 20 to the respective detonators at the relevant holes, utilizing the relevant identification codes of the detonators at the holes as addresses. The delay time data is stored in the RAM of each local controller 30.

[0041] The next step is to transmit a common fire signal on line 20 to all the detonators simultaneously. The local timers 24 in each of the detonators then time out the delay times stored in the RAM and associated with the detonator, before the local controller 30 causes the switch 28 to close, to cause the charge in the capacitor 26 to be dumped in the fuse, to activate the detonator, to cause the associated explosive charge to explode as part of the multi-shot blast.

[0042] In the embodiment shown in figure 4, the electrical communication line 20 is replaced by a radio frequency (RF) link. The controller 116 comprises a RF transmitter (not shown) and antenna 38 and each detonator 114.1 to 114.8 comprises a RF receiver (not shown) and an antenna 40.1 to 40.8 respectively. In this embodiment the bar code reader and data-capturing device may be incorporated in a single portable unit 36. The unit 36 is connectable to the controller 116 and the GPS receiver 19 is connectable to the unit 36, to download the GPS data.

[0043] In this embodiment the energizing signal, the delay time data and the common fire signal are transmitted via the RF link.

[0044] In another embodiment of the method, the position related data is inputted manually or automatically into a central controller. Upon such inputting of the data, the controller automatically determines the firing sequence and delay times. The delay times are then timed out by the controller (which preferably is remote from the detonators and associated charges) and fire signals are transmitted sequentially by the controller to the detonators in accordance with the desired firing sequence.

[0045] It will be appreciated that there are many variations in detail on the explosive firing system and method according to the invention without departing from the spirit of the appended claims.

Claims

1. A method of causing a multi-shot blast including the steps of:
   - selecting a plurality of spaced positions for locating detonators in a blast site;
   - at each position, determining position related data for that detonator position;
   - utilizing the position related data to establish a blast programme; and
   - providing signals to detonators at the detonator positions to cause them to detonate according to the programme.

2. A method as claimed in claim 1 also including the step of determining identification code data of each of the detonators before establishing the blast programme.

3. A method as claimed in claim 2 wherein the identification code data is determined by reading the data electronically from a memory arrangement forming part of the detonator.

4. A method as claimed in claim 2 wherein the identification code data is determined passively.

5. A method as claimed in claim 4 wherein the identification code data is provided in the form of a bar code pattern on the detonator and wherein the bar code pattern is read by a bar code reader.

6. A method as claimed in any one of claims 1 to 5 wherein the position related data is determined by determining distances between the detonator positions.

7. A method as claimed in any one of claims 1 to 5 wherein the position related data is determined by determining position coordinate data for each detonator position.

8. A method as claimed in claim 7 wherein the position coordinate data is determined utilizing a global positioning system (GPS) including a GPS receiver and at least one earth orbiting satellite.

9. A method as claimed in any one of claims 2 to 8 wherein the position related data and identification code data are captured in a data reading, storing and downloading device.

10. A method as claimed in claim 9 wherein the captured data is downloaded into a central controller for establishing the blast programme.

11. A method as claimed in any one of claims 1 to 10 wherein the step of providing signals to the detonators includes the step of transmitting to each of the detonators, utilizing its respective identification code data as an address, d lay item data relating to a delay time from a common fir signal for each

detonator to detonate.

12. A method as claimed in claim 11 wherein before the delay time data is transmitted to the detonators, th detonators are energized by transmitting an energizing signal to the detonatore.

13. A method of timing a multi-shot blast including the steps of:

- locating a detonator arrangement including a detonator having a preprogrammed identification code; and an associated explosive charge, in each of a plurality of spaced detonator positions;
- at each position, determining respective detonator identification code data relating to the detonator at that position and respective position related data for that detonator position;
- transferring the respective detonator identification code data and respective position related data to a central controller;
- computing for each detonator position, data relating to a respective delay time from reception of a common fire signal after which the detonator at that detonator position must cause its associated charge to explode;
- utilizing the respective detonator identification code data and transmitting the respective delay time data to each detonator at said detonator positions; and
- transmitting a common fire signal to each detonator, to cause its associated charge to explode after the respective delay time computed for that detonator position.

14. A method of preparing a blast site, the method including the steps of:

- selecting a plurality of spaced positions for locating electronic detonators;
- at each position determining position related data for that detonator position; and
- transferring the position related data to a central controller.

15. A method of causing a multi-shot blasting operation of a series of explosive charges spaced apart from each other at a blast site, said method including the steps of:

- automatically determining position related data at each charge location;
- determining from the positional data a required firing sequence; and
- applying the firing sequence to the series of charges.

16. A method according to claim 15, in which the automatic determination of position related data at each charge location is obtained using one of: a radio device; an acoustic device; an optical device; a laser operated device; or a global positioning system receiver.

17. A method according to claim 16, in which the position related data is determined by absolute position monitoring.

18. A method according to claim 16, in which the position related data is determined by distance-related monitoring.

19. A method according to any one of claims 15 to 18, in which the required firing sequence is determined from the positional data by manual or automatic inputting of the data to a data store.

20. A method according to claim 19, in which the data store is connected to, or incorporated in a remote controller which is operative to send sequential firing signals to the individual charges according to the required firing sequence.

21. A method according to claim 19, in which the data store supplies respective firing sequence data to individual local controllers associated one with each charge, and upon issue of a common firing signal to the local controllers, sequential firing of the charges takes place according to the required firing sequence.

22. An explosive firing system including:

- a plurality of detonators;
- a central controller for controlling operation of the detonators;
- position determining means for determining position related data for each of a plurality of suitable positions for the detonators in a blast area;
- the central controller being arranged to utilize said position related data to compute a blast programme;
- means for transferring signals relating to the blast programme to the detonators to cause them to detonate in accordance with the blast programme.

23. A system as claimed in claim 22 wherein the controller in computing the blast programme computes for each position, delay time data relating to a delay time from reception of a common fire signal after which a detonator at that position must cause an associated charge to explode.

24. A system as claimed in claim 22 or claim 23 also

including means for inputting identification code data associated with each detonator.

25. A system as claimed in any one of claims 22 to 24 wherein the position determining means includes a global positioning system (GPS) including a GPS receiver cooperating with at least one earth orbiting satellite.

26. A system as claimed in any one of claims 22 to 25 also including a data capturing device for receiving position related data and identification code data at the detonator position and for downloading said data into the central controller.

27. A system as claimed in any one of claims 22 to 26 wherein the signal transferring means includes a wired communication path between the controller and the detonatore.

28. A system as claimed in any one of claims 22 to 26 wherein the signal transferring means includes a radio frequency link between the controller and the detonators.

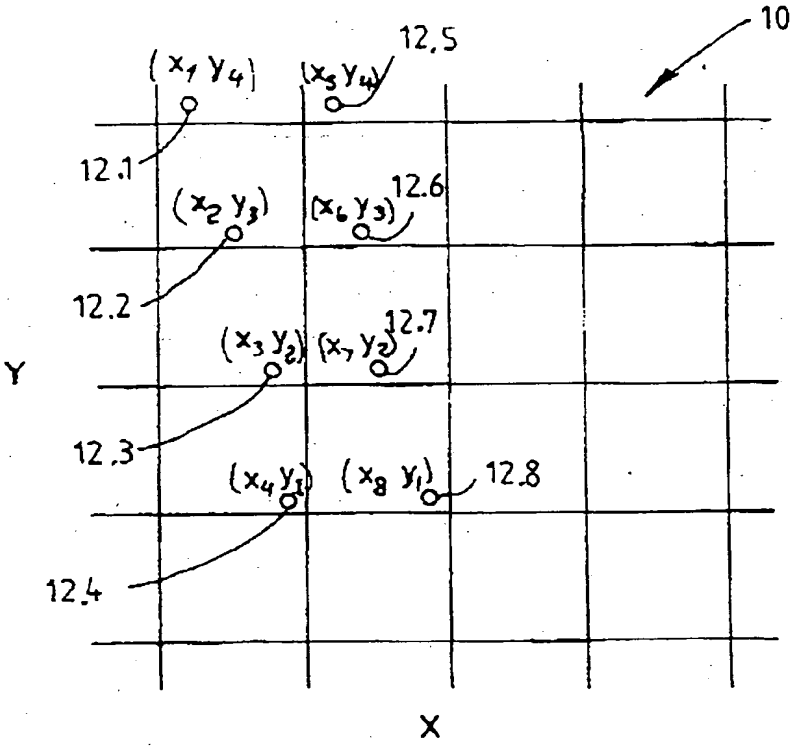
10
12.5
$(x_1\ y_4)$
$(x_5\ y_4)$
12.1
$(x_2\ y_3)$
$(x_6\ y_3)$
12.6
12.2
$(x_3\ y_2)$
$(x_7\ y_2)$
12.7
Y
12.3
$(x_4\ y_1)$
$(x_8\ y_1)$
12.8
12.4
X

FIGURE 1

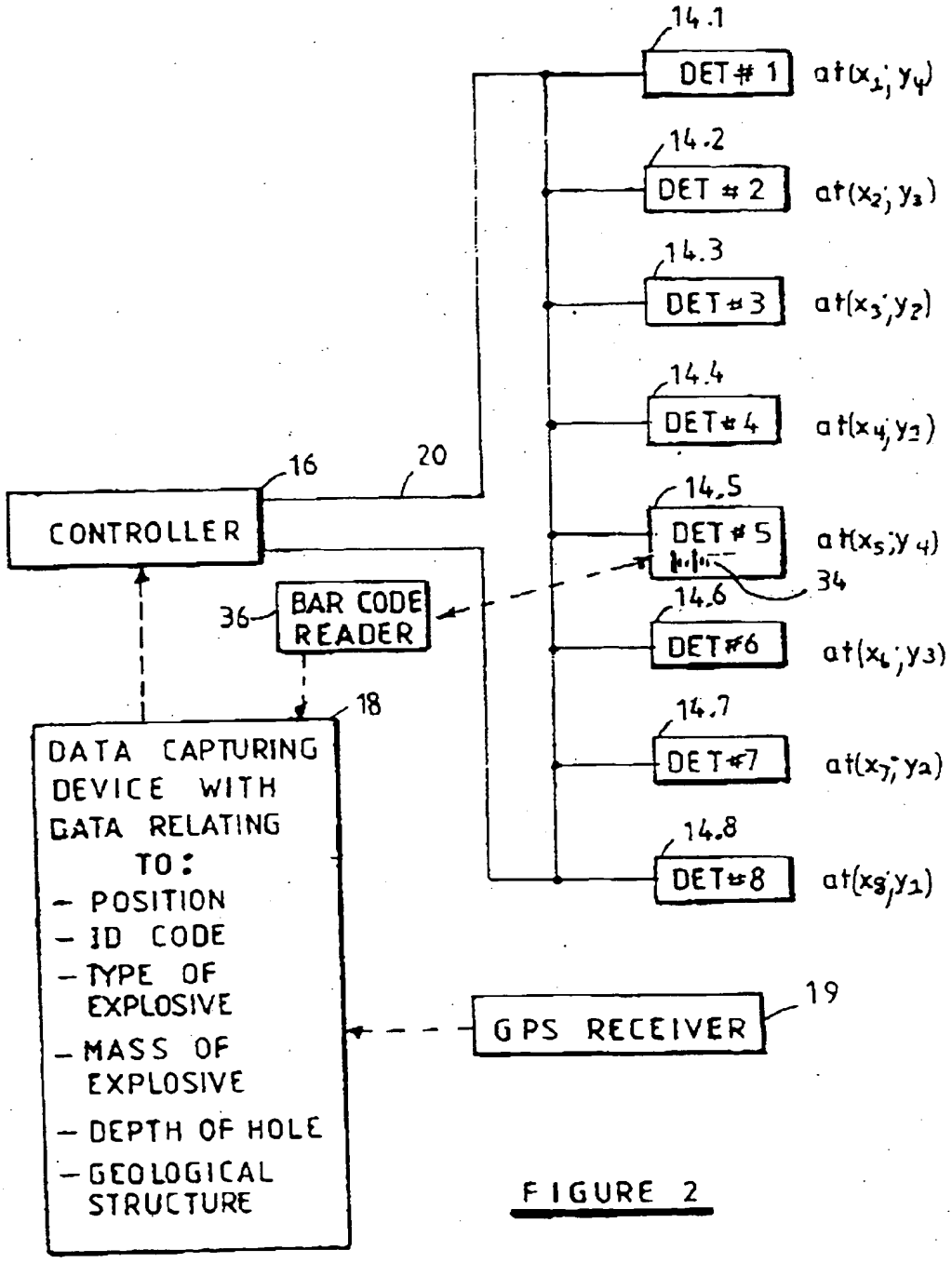
14.1
DET # 1
at (x1; y4)
14.2
DET # 2
at (x2; y3)
14.3
DET # 3
at (x3; y2)
14.4
DET # 4
at (x4; y1)
16
20
CONTROLLER
14.5
DET # 5
at (x5; y4)
34
36
BAR CODE READER
14.6
DET # 6
at (x6; y3)
18
14.7
DET # 7
at (x7; y2)
DATA CAPTURING DEVICE WITH DATA RELATING TO:
- POSITION
- ID CODE
- TYPE OF EXPLOSIVE
- MASS OF EXPLOSIVE
- DEPTH OF HOLE
- GEOLOGICAL STRUCTURE
14.8
DET # 8
at (x8; y1)
19
GPS RECEIVER

FIGURE 2

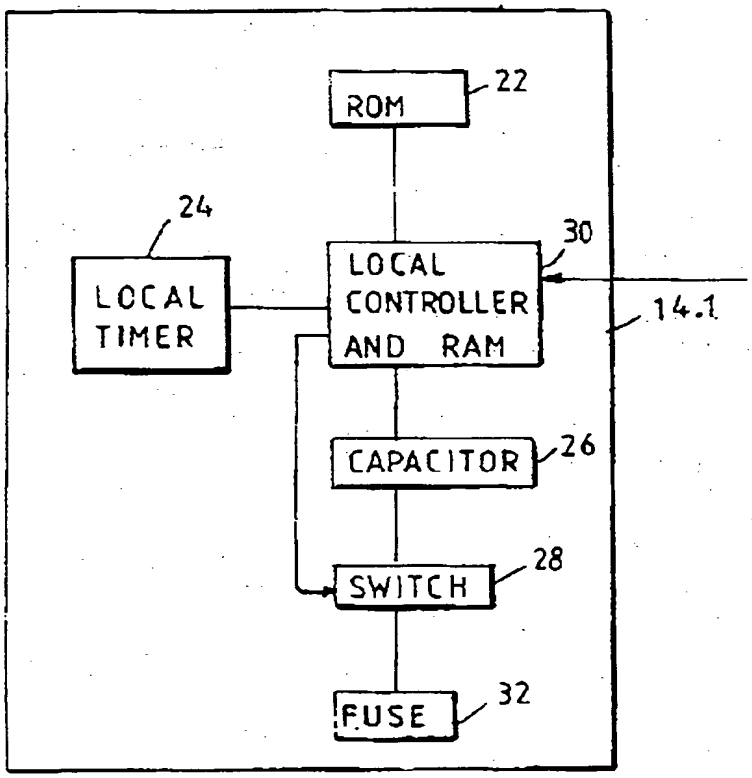
ROM
22
24
LOCAL TIMER
30
LOCAL CONTROLLER AND RAM
14.1
CAPACITOR
26
SWITCH
28
FUSE
32

FIGURE 3

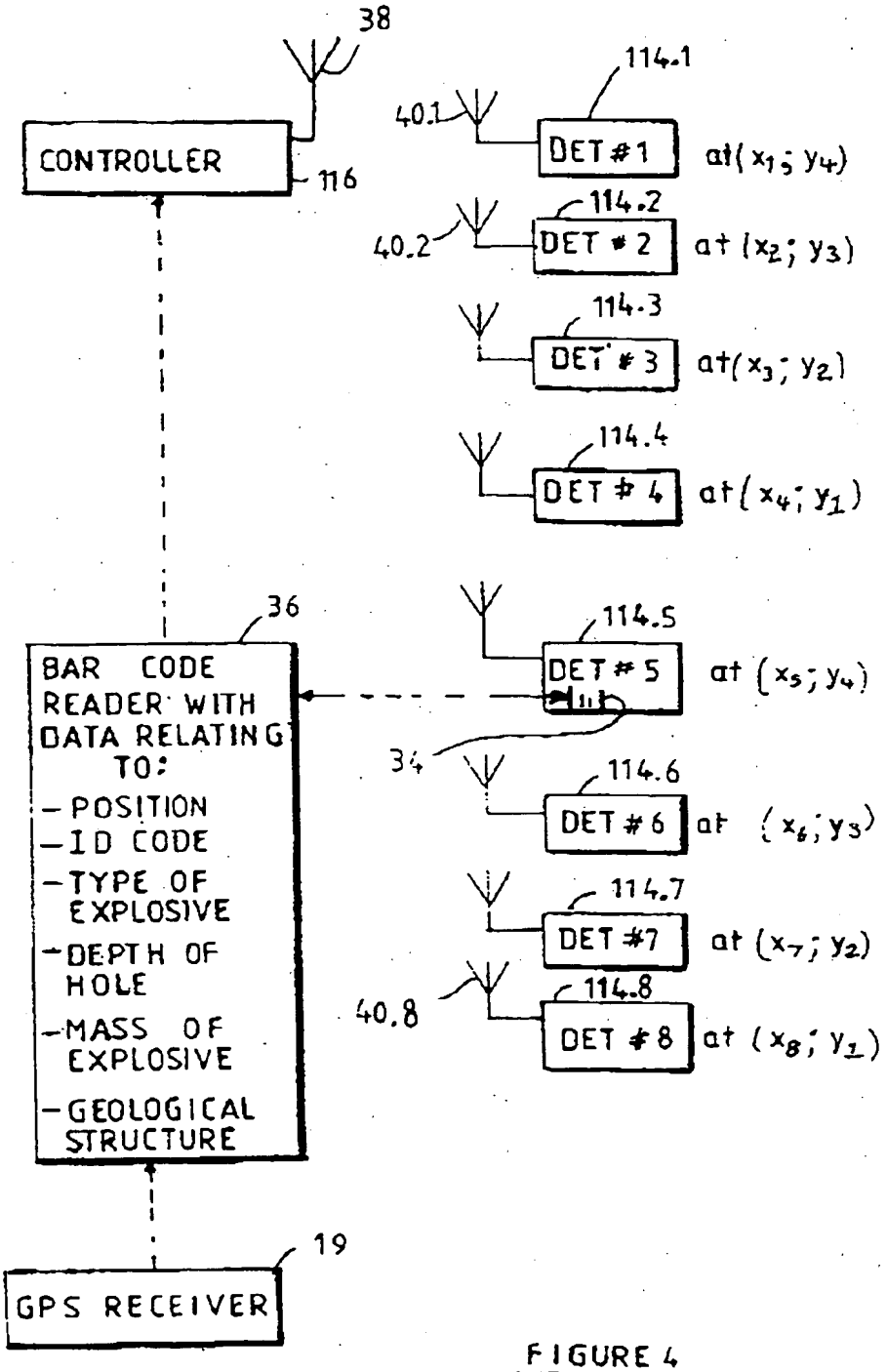
38
CONTROLLER
116
36
BAR CODE READER WITH DATA RELATING TO:
- POSITION
- ID CODE
- TYPE OF EXPLOSIVE
- DEPTH OF HOLE
- MASS OF EXPLOSIVE
- GEOLOGICAL STRUCTURE
19
GPS RECEIVER
34
40.1
114.1
DET #1
at (x1; y4)
40.2
114.2
DET #2
at (x2; y3)
114.3
DET #3
at (x3; y2)
114.4
DET #4
at (x4; y1)
114.5
DET #5
at (x5; y4)
114.6
DET #6
at (x6; y3)
114.7
DET #7
at (x7; y2)
40.8
114.8
DET #8
at (x8; y1)

FIGURE 4